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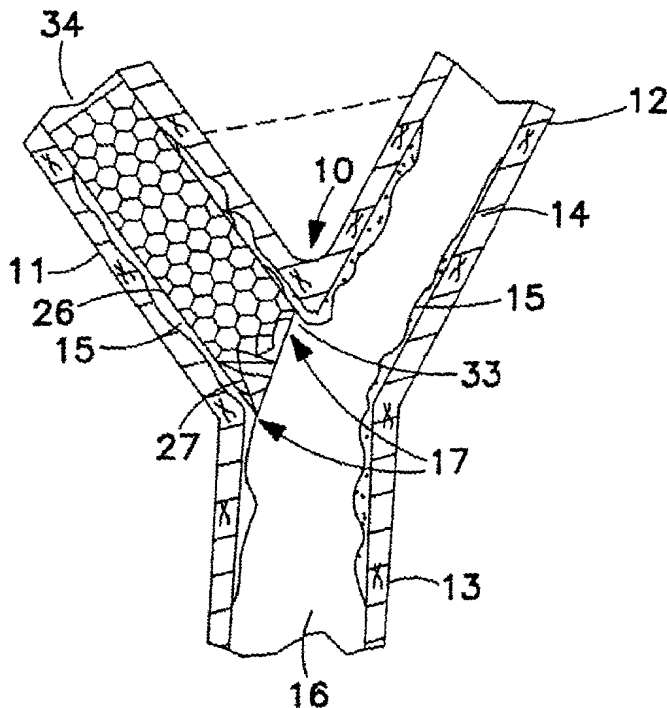
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(54) Title: **ANGULAR VASCULAR STENT**



(57) **Abstract:** This invention is a method, and device for treating one or more vessels at a bifurcation (10) without blocking or restricting the flow of blood; an expandable and deformable stent (25) having a cylindrical body; and an angled portion (27) at one or both ends. The angled stent (25) is located, and oriented at the bifurcation (10) so that when expanded the cylindrical body and the angled proximal end (27) fully support the first vessel without compromising or interfering with the second vessel. One or more of such angled stent (25) may be deployed at a bifurcation (10).

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**(15) Information about Correction:**

see PCT Gazette No. 05/2002 of 31 January 2002, Section II

## ANGULAR VASCULAR STENT

### FIELD OF THE INVENTION

The present invention relates to stent to be used in a bifurcating vessel, and, more particularly, to an expandable and deformable stent having a cylindrical body and an angled portion at one or both ends and a method for using same.

### BACKGROUND OF THE INVENTION

A stent is used for treating occlusions, stenoses, or aneurysms in a blood vessel. Typically, the stent is compressed and implanted in a blood vessel, artery or vein, at the site of the stenosis or other restriction to reinforce and support collapsing, occluded or weakened sections of the vessel. Once in position in the blood vessel, the stent is expanded, dilating the vessel at the site and enabling the blood to flow more freely through the vessel.

While generally satisfactory for the treatment of sites in continuous or unbifurcated portions of the vessels, arteries or veins, prior art stents are not well suited where the site of the desired treatment is located at or across a bifurcation. One of the difficulties with conventional stents is that they are produced in a straight tubular configuration, employing features with "squared off ends". The implantation of the conventional stent in one branch at or near a bifurcation can result in either positioning a portion of one end of the stent extending into or across the bifurcation thereby obstructing or compromising the other branch and/or the bifurcation, restricting the blood flow and leading to an unfavorable result. On the other hand, by locating the other end of the stent sufficiently away from the bifurcation so as not to interfere with or obstruct the other branch, the damaged or diseased bifurcating vessel is not fully treated.

U.S. Patent No. 4,994,071 discloses a bifurcating stent which includes a structure, particularly a series of interconnected loops defining a first flow path and an additional structure, using a second series of interconnected loops defining a second branching flow path. An interconnection joins the structures that define the first and second flow paths which is then bent to conform to the shape of the vessel.

U.S. Patent No. 5,607,444 discloses an expandable stent which is constituted of a tubular member having and portion that is flared. The stent is placed within the bifurcated vessel to be repaired with the flared portion extending beyond the junction

1 of the bifurcation and into the other branch. The flared portion is then "capped" or  
2 folded back along the wall of the other branch at the bifurcation.

3 U.S. Patent No. 5,938,696 discloses stents for use at a bifurcation comprised  
4 of a first stent including a proximal engaging portion which may be flared and a  
5 second stent providing a cooperating portion to accept the engaging portion. In use at  
6 least one of the stents extends across the bifurcation into another branch vessel.

7 However, the prior art stents do not satisfactorily correct the stenosis at the  
8 bifurcation. In order to overcome these problems, a stent that will expand in  
9 juxtaposition with a bifurcation, treating the entire damaged or diseased vessel and  
10 without extending into the bifurcation or overlapping into the other branch, without  
11 restricting or blocking the pathway or risking damage to the bifurcation and other  
12 branch is needed.

### 13 SUMMARY OF THE INVENTION

14 The present invention is directed to an angled stent device for treating one or  
15 more vessels at a bifurcation without blocking or restricting access or blood flow to  
16 the bifurcation or other vessels. The invention also provides a method for using the  
17 stent.

18 The stent is comprised of an expandable cylindrical portion and an angled  
19 portion at one or both ends. The stent is constructed of a material capable of radial  
20 expansion and having sufficient strength to retain its shape after expansion and to  
21 support the most proximal end of the angled portion. In the preferred embodiment,  
22 the cylindrical portion has a symmetrical geometric pattern which facilitates the  
23 expansion while providing the required strength. The angled portion of the stent  
24 extends from the cylindrical portion, the angled portion being configured at an angle  
25 substantially approximating the angle established at the bifurcation by the junction of  
26 the bifurcated vessel and the other branch, once expanded. The expansion of the  
27 angled portion at or near the bifurcation is consistent with the expansion of the  
28 cylindrical portion. Preferably, the angled portion has an asymmetrical geometric  
29 pattern and is constructed of the same material as the cylindrical portion.  
30 Alternatively, the angled portion may be constructed of a different material or may be  
31 implanted apart from the cylindrical portion.

1           A preferred use of the angled stent is accomplished by means of a balloon  
2 catheter. The stent is arranged coaxially on the balloon with the angled portion on  
3 the proximal portion of the balloon and the cylindrical portion on the distal portion of  
4 the balloon. Alternatively, depending upon the introduction of the stent at the  
5 bifurcation, these position can be reversed. The balloon-stent assembly is arranged  
6 on the catheter and is advanced to the location of treatment within the vessel. In the  
7 preferred embodiment, a radio-opaque marker is arranged on one end of the balloon  
8 adjacent to the angled portion of the stent. A buttress or stop cap is arranged on the  
9 on the distal end of the balloon to retain the stent in position on the balloon. The  
10 desired location and orientation of the balloon-stent assembly is achieved by means  
11 of radiography. Once the balloon-stent assembly is in position, the balloon is  
12 expanded, deploying the expanded stent within the vessel such that of the angled  
13 portion is in juxtaposition with the bifurcation and together with the cylindrical  
14 portion fully supports the damaged or diseased portion of the bifurcated vessel  
15 without extending across or into the bifurcation or the other vessel. Following  
16 deployment of the stent, the balloon is deflated and the balloon, radio-opaque marker,  
17 stop cap and catheter are removed from the patient.

18           It will be appreciated that a stent according to the invention would have the  
19 advantage of fully treating the damaged or diseased vessel at or near the bifurcation  
20 without compromising or obstructing the blood flow in other portions of the  
21 bifurcation. A further advantage is that such stent will allow access to and will not  
22 interfere with any treatment introduced or delivered to the bifurcation or other vessel.  
23 Another advantage of a stent according to the invention is that such stents, having the  
24 same or different angles or shapes, or combination of angles or shapes, for example  
25 frustoconical, at one end may be used in more than one branch at a bifurcation  
26 without extending into, obstructing or compromising the bifurcation, and without  
27 overlapping an adjacent branch or stent.

28           These and other objects, features and advantages of the present invention will  
29 be better understood with reference to the detailed description of the preferred  
30 embodiment and the accompanying drawings.

1                                    BRIEF DESCRIPTION OF THE DRAWINGS

2                    FIGS. 1a and 1b show conventional stent devices of the prior art in an  
3                    expanded configuration at a bifurcation;

4                    FIG. 2 is a side view of one embodiment of the angled stent device of the  
5                    present invention in an unexpanded configuration;

6                    FIG. 3 is a side view of the unexpanded angled stent according to the present  
7                    invention arranged on a balloon catheter;

8                    FIG. 4 shows a side view of the unexpanded angled stent of FIGS. 2 and 3,  
9                    illustrating a preferred method of placement of the stent at a bifurcation;

10                   FIG. 5 shows one embodiment of the angled stent device of the present  
11                   invention in an expanded configuration;

12                   FIGS. 6 and 7 are side views of alternative embodiments of the present  
13                   invention;

14                   FIG. 8 shows another embodiment of the present invention.

15                   DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENT

16                   The present invention includes a device and method for treating one or more  
17                   vessels at a bifurcation without blocking or restricting access or blood flow to the  
18                   bifurcation or other vessels.

19                   As shown in FIGS. 1a and 1b conventional stents 5 are produced in a straight  
20                   tubular configuration having squared off ends 3. FIG. 1a depicts conventional stent 5  
21                   in its expanded form, implanted in a bifurcated vessel 11 at or near a bifurcation 10  
22                   opening up the restriction to interior arterial passage 16 caused by stenosis 15 and  
23                   providing support for the vascular wall 14. By attempting to fully treat the diseased  
24                   or damaged vessel 11, proximal end 33 of conventional stent 5 extends into the  
25                   bifurcation 10 and junction 17 thereby obstructing branches 12, 13, restricting the  
26                   blood flow. FIG. 1b shows prior art stent 5 after expansion, positioned in bifurcated  
27                   vessel 11 with the end 33 sufficiently remote from the bifurcation 10 and junction 17  
28                   so as not to extend into the bifurcation. However, the damaged or diseased bifurcated  
29                   vessel 11 is not fully treated as the stent 5 does not reach portions of junction 17 of  
30                   the bifurcation.

1           An angular stent 25 according to the present invention which is depicted in  
2 FIG. 2 provides for the complete treatment of a diseased or damaged bifurcated vessel  
3 without obstructing the bifurcation.

4           As shown in FIG. 2, angular stent 25 is comprised of expandable cylindrical  
5 portion 26 and expandable angled portion 27 at the proximal end 33. Preferably, the  
6 angular stent 25 is constructed of a material capable of radial expansion and having  
7 sufficient strength to retain its shape after expansion and to support the most proximal  
8 end of the angled portion 27. In the preferred embodiment, the cylindrical portion 26  
9 has a symmetrical geometric pattern which facilitates the expansion while providing  
10 the required strength. The angled portion 27 of stent 25 extends from cylindrical  
11 portion 26, substantially parallel to longitudinal axis 28, end 33 of the angled portion  
12 27 being configured at an angle substantially approximating the angle established at  
13 the bifurcation 10 by the junction 17 of the bifurcated vessel 11 and the other  
14 branches 12, 13, once expanded. The expansion of the angled portion 27 at or near  
15 the bifurcation 10 is consistent with the expansion of the cylindrical portion 26 of the  
16 stent. Advantageously, the stent may be produced having any angle or combination  
17 of angles at one or both ends. Accordingly, the stent and or angled portion of the  
18 stent best approximating the angle established by the junction of the vessel or vessels  
19 to be treated and the other branch or branches of the bifurcation may be selected for  
20 implantation.

21           Preferably, the angled portion 27 has an asymmetrical geometric pattern and is  
22 constructed of the same material as the cylindrical portion 26. Alternatively, the  
23 angled portion may be constructed of a different material or may be implanted apart  
24 from the cylindrical portion.

25           A preferred use of the angled stent 25 according to the invention is  
26 accomplished by means of a balloon catheter 35. Unexpanded stent 25 is arranged  
27 coaxially on balloon 32 with the angled portion 27 at end 33 portion of the balloon 32  
28 and the cylindrical portion 26 of the stent 25 at the distal portion 34 of the balloon.  
29 Tubular portion 36 extends from the end of balloon 32 as a conduit allowing for  
30 inflation and deflation. Guide wire 29 extends the length tubular portion 36 and  
31 balloon 32. In the preferred embodiment, expandable radio-opaque marker 30 is  
32 arranged at the end 33 of the balloon 32 adjacent to the angled portion 27 of the stent

1 25, the adjacent end of the marker 30' being angled correspondent to the end of  
2 angled portion of the stent. Proximal angular stop 30' may be arranged on balloon 32  
3 between the end of the angled portion 27 and the radio-opaque marker 30' to maintain  
4 the alignment and positioning of the stent 25 on the balloon catheter 35. A buttress  
5 or stop cap 31, which may also be radio-opaque, is arranged on the on the distal end 34  
6 of the balloon 32 to retain the stent 25 in position on the balloon. Further, the radio-  
7 opaque marker 30' and buttress or stop cap 31 enable the physician or radiographer to  
8 observe the placement and orientation of the stent and balloon catheter assembly  
9 within the arterial passageway and the bifurcated vessel.

10 As shown in FIG. 4, the unexpanded stent 25 and balloon catheter 35  
11 assembly is advanced, for example, through interior arterial passageway 16, to the  
12 intended location of treatment within the bifurcated vessel 11. By use of radiography,  
13 the radio-opaque marker 30' and the stop cap 31 are observed and the unexpanded  
14 angular stent 25 is advanced into the desired position within the bifurcated vessel 11.  
15 Once the stent 25 is in position balloon 32 is expanded, deploying the expanded  
16 angular stent 25 within the vessel 11 such that the end 33 of the angled portion 27 of  
17 the stent is in juxtaposition with junction 17 of bifurcation 10 and together with the  
18 cylindrical portion 26 fully supports the damaged or diseased portion of the bifurcated  
19 vessel 11 without extending across or into the bifurcation 10 or the other vessels 12,  
20 13. Following expansion and deployment of the stent, the balloon is deflated and the  
21 balloon, radio-opaque marker, stop cap and catheter are removed from the patient, as  
22 shown in FIG. 5. In this way diseased or damaged vessel 11 is completely treated and  
23 blood flow is not obstructed or restricted by any portion of the stent or overlapping,  
24 allowing access for any treatment introduced or delivered to the bifurcation or other  
25 vessels without interference. Alternatively, depending upon the introduction of the  
26 stent to the bifurcation 10, the arrangement of the stent, the radio-opaque marker and  
27 the stop cap on the balloon catheter may be reversed.

28 Another embodiment of the present invention is the use of angular stents in  
29 two branches of the bifurcation. FIG. 6 shows a dual stent application in accordance  
30 with the invention. Similar to the implantation of angled stent 25 in the bifurcated  
31 vessel 11 as depicted in FIGS. 3 and 4, the angular stents in a dual application may  
32 completely treat the diseased or damaged sites without interfering with or overlapping



1 the other stent and without extending into the bifurcation or otherwise obstructing or  
2 restricting the blood flow.

3 FIG. 7 depicts another embodiment, an angular stent 25 according to the  
4 invention, after expansion is in position in the bifurcated vessel 11 and a conventional  
5 stent 5, is implanted in the bifurcation. In this way the bifurcation is treated and the  
6 stents are not compromised.

7 In another embodiment, an example of additional or subsequent treatment to a  
8 repaired bifurcation area is shown. FIG. 8 shows dual angular stents 25 implanted  
9 and deployed in branches 11 and 12. Stent 25' including an angled portion 27 having  
10 a frustoconical configuration 40 is implanted in other branch 13. Although the end 40  
11 of the angled portion of stent 25' extends into the bifurcation, as a result of the  
12 configuration of the angled stents the diseased or damages vessels are completely  
13 treated without any such stent obstructing or compromising the bifurcation or  
14 overlapping an adjacent branch or stent.

15 It will be appreciated that the angular stent according to the invention enable  
16 full treatment of the damaged or diseased vessel at or near the bifurcation without  
17 compromising or obstructing the blood flow in other portions of the bifurcation  
18 vessel. It will also be appreciated that the angular stent according to the invention  
19 may be produced having a variety of angles or combination of angles or shapes, and  
20 may be used in more than one branch at a bifurcation without extending into,  
21 obstructing or compromising the bifurcation, and without overlapping an adjacent  
22 branch or stent.

23 Although described in terms of the presently preferred embodiment, those  
24 skilled in the art will appreciate that the present invention is not limited to the  
25 embodiment described.

CLAIMS

- 1 1. A stent comprising, a cylindrical portion having two ends wherein at least one  
2 said end having an angled portion forming an angle with respect to a longitudinal axis  
3 of said cylindrical portion.
- 4 2. A stent as claimed in claim 1, wherein said cylindrical portion and said angled  
5 portion being expandable in a radial direction about said longitudinal axis,
- 6 3. A stent as claimed in claim 1, wherein said angle approximating an angle  
7 established at a bifurcation by a junction of two or more bifurcated vessels.
- 8 4. A stent as claimed in claim 1, wherein said cylindrical portion and said angled  
9 portion are constructed of a flexible material capable of radial expansion, said  
10 material having sufficient strength to retain its shape after expansion and to support  
11 the most proximal end of the angled portion.
- 12 5. A stent as claimed in claim 1, wherein the cylindrical portion is symmetrical  
13 about said longitudinal axis
- 14 6. A stent as claimed in claim 1, wherein said angled portion expands  
15 consistently with the expansion of the cylindrical portion.
- 16 7. A stent as claimed in claim 1, wherein the angled portion is constructed of the  
17 same material as the cylindrical portion and formed as a single unit.
- 18 8. A stent as claimed in claim 1, wherein the angled portion is constructed of a  
19 different material than the cylindrical portion.
- 20 9. A method for using an angular stent, comprising the steps of:  
21 arranging an unexpanded stent having a cylindrical portion and an angular  
22 portion coaxially on a balloon catheter, the balloon having tubular portion and two  
23 end portions;  
24 arranging the cylindrical portion of the stent is on the tubular portion of the  
25 balloon;  
26 arranging the angled portion of the stent at an end portion of the balloon,  
27 arranging an expandable marker on one end of the balloon adjacent to said  
28 angled portion and;  
29 arranging an expandable stop cap on the other end portion of the balloon.  
30

1 10. The method of claim 9, further comprising the step of advancing the  
2 unexpanded stent and balloon catheter to an intended location in a vessel and  
3 positioning said stent by observing the expandable marker and the stop cap.

4 11. The method of claim 9, further comprising the step of expanding the balloon  
5 and deploying the expanded angular stent such that the end of the angled portion of  
6 the stent is in juxtaposition with a junction of a bifurcation.

7 12. The method of claim 9, further comprising the step of deflating the balloon  
8 and removing the balloon, expandable marker, expandable stop cap and catheter are  
9 from the patient.

10 13. The method of claim 9, wherein the expandable marker and/or the expandable  
11 stop cap are radio-opaque.

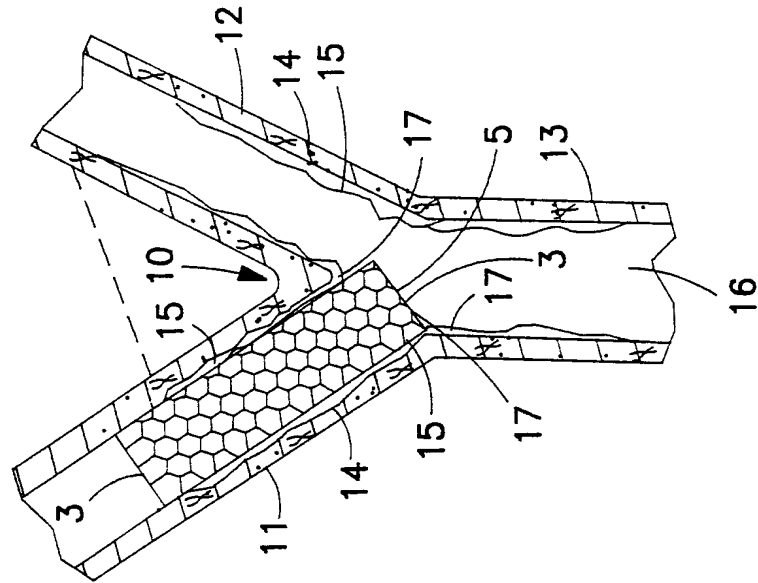
12 14. The method of claim 9, wherein the expandable marker is arranged on the end  
13 portion of the balloon.

14 15. The method of claim 9, wherein the adjacent end of the expandable marker is  
15 angled correspondent to the end of angled portion of the stent.

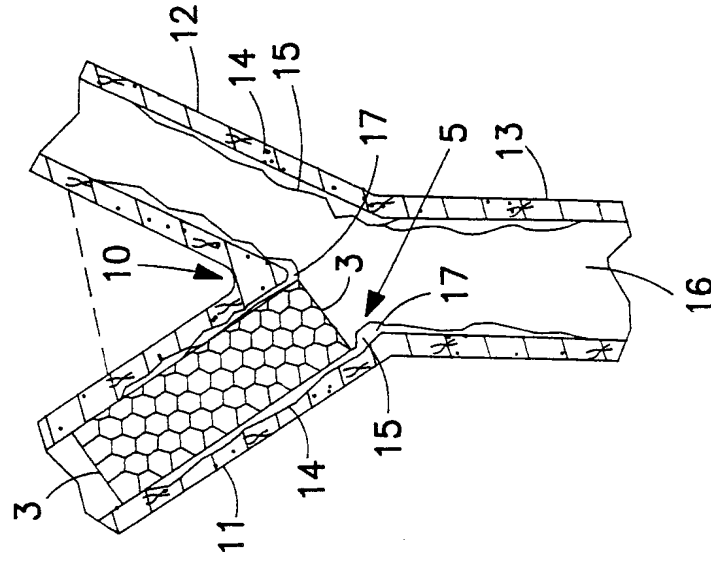
16 16. The method of claim 9, wherein the expandable marker is arranged on the  
17 distal end portion of the balloon.

18 17. The method of claim 9, wherein the adjacent end of the expandable marker is  
19 angled with respect to the distal end of angled portion of the stent.

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**FIG. 1a**  
PRIOR ART



**FIG. 1b**  
PRIOR ART

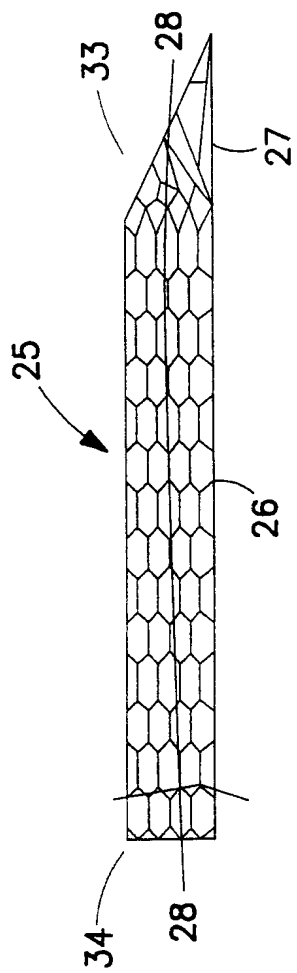


FIG. 2

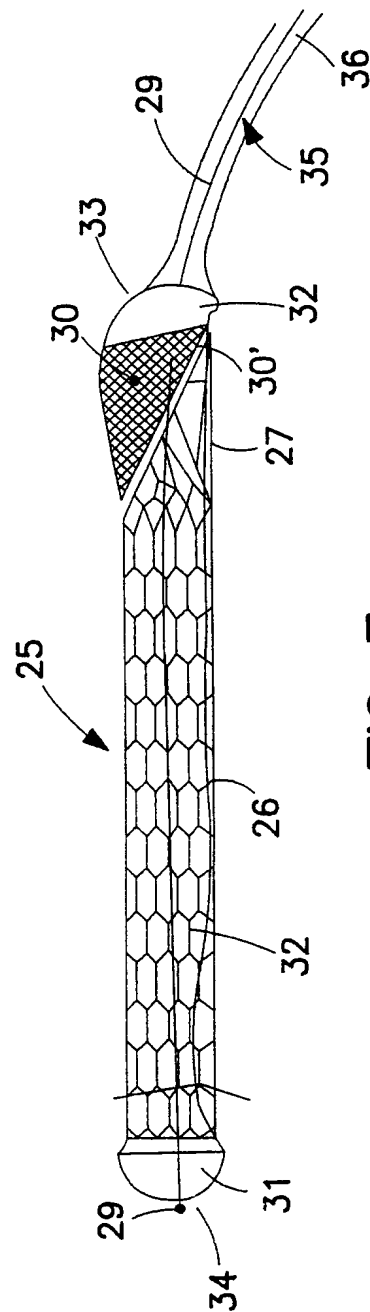


FIG. 3

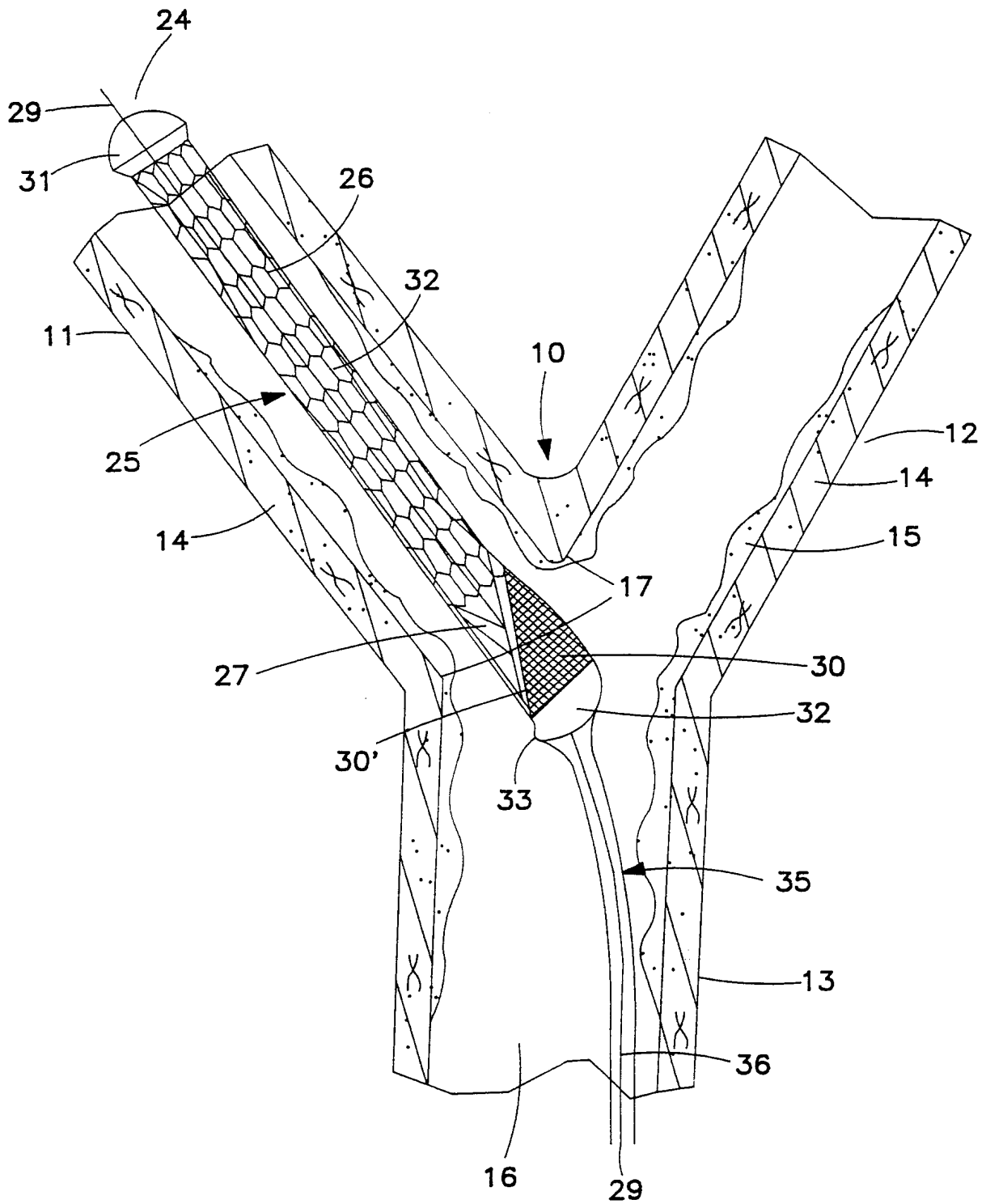


FIG. 4

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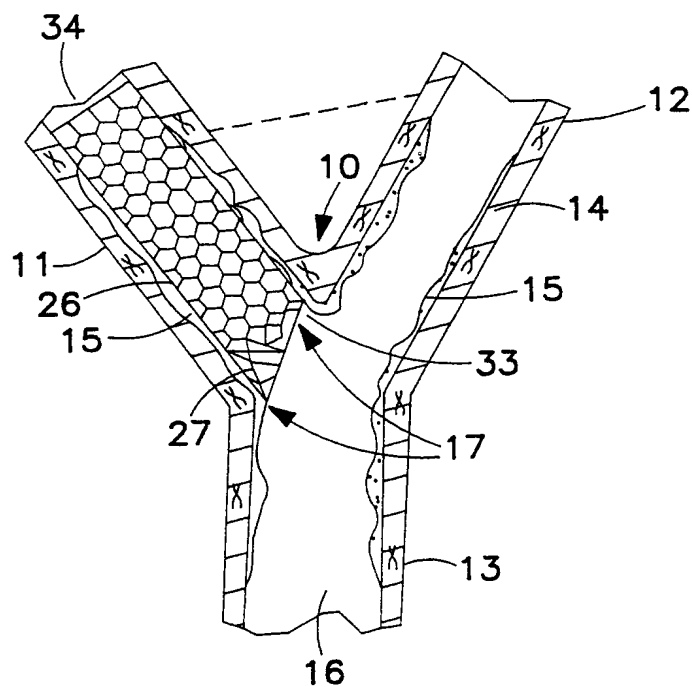


FIG. 5

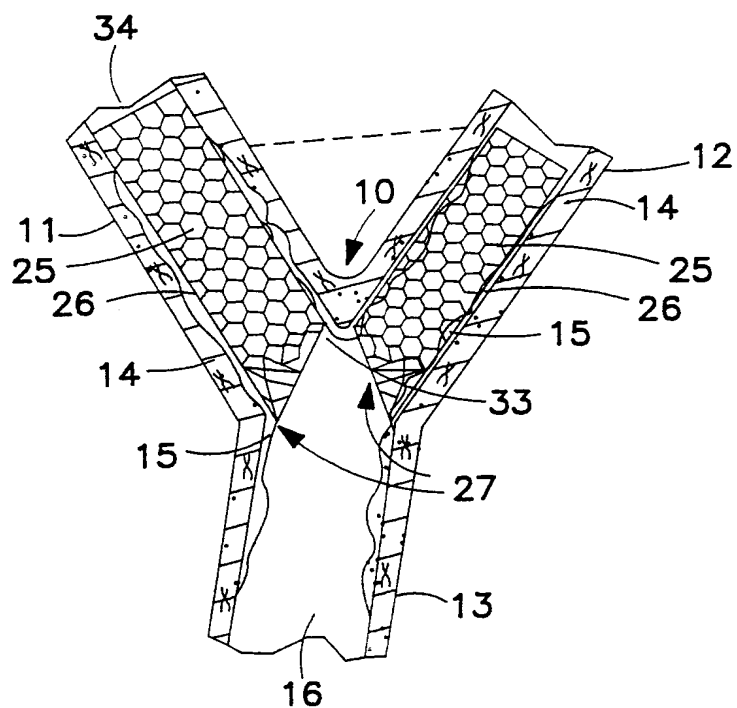


FIG. 6

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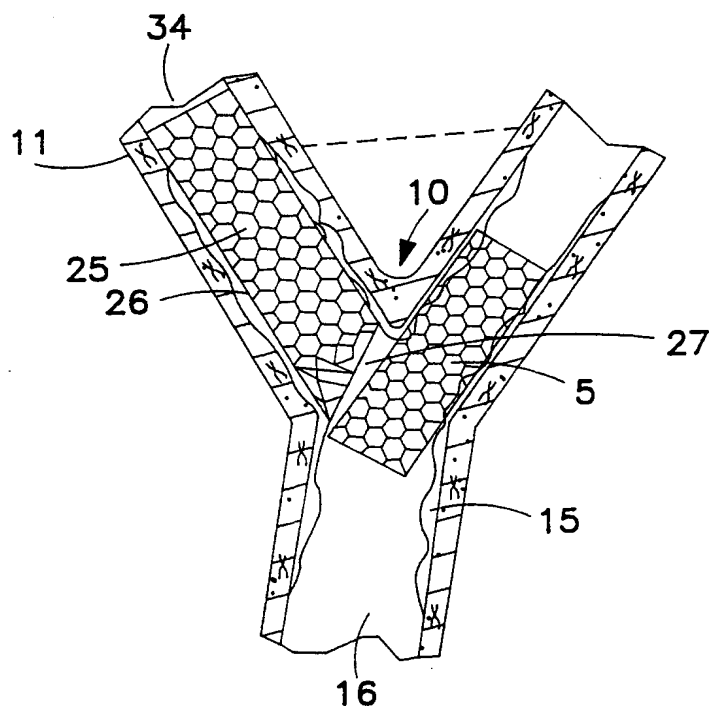


FIG. 7

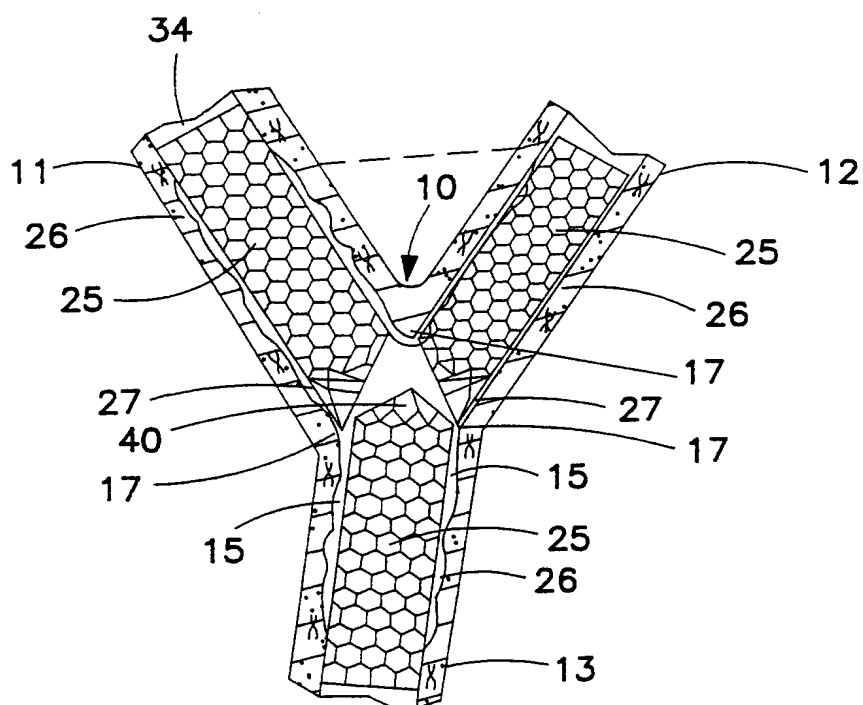


FIG. 8



## INTERNATIONAL SEARCH REPORT

International application No.

PCT/US00/08482

**A. CLASSIFICATION OF SUBJECT MATTER**

IPC(7) : A61F 2/00

US CL : 623/1

According to International Patent Classification (IPC) or to both national classification and IPC

**B. FIELDS SEARCHED**

Minimum documentation searched (classification system followed by classification symbols)

U.S. : 623/1, 11, 12

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

**C. DOCUMENTS CONSIDERED TO BE RELEVANT**

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A, P	US 5,893,887 A (JAYARAMAN) 13 April 1999, entire document.	1-17
A, P	US 5,906,640 A (PENN et al.) 25 May 1999, entire document.	1-17

☐ Further documents are listed in the continuation of Box C.
 ☐ See patent family annex.

* Special categories of cited documents:	"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
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Date of the actual completion of the international search

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Date of mailing of the international search report

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